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PRACTICAL BACTERIOLOGY

An Introduction to Practical Bacteriology, based upon the Methods of Koch. By Edgar M. Crookshank, M.B. (Lond.), F.R.M.S., Demonstrator of Physiology, King's College, London. (London: H. K. Lewis, 1886.)

THIS excellent work is based upon notes made in different Continental laboratories, and is intended to be a laboratory hand-book as well as a text-book of bacteriology, including as it does "a systematic sketch of the genera and species of micro-organisms, as well as the methods employed in the investigation of their life-histories." The science is intimately connected with the etiology of the infectious and contagious diseases, and by enlarging knowledge as to the origin, causes, and spread of these diseases, has greatly aided, and may be expected in the future greatly more to aid, in the acquisition of knowledge as to the measures necessary to be adopted for their prevention; nevertheless it has received attention in this country from but a few earnest inquirers, the great mass of information now at our disposal having been accumulated in Germany. This fact is apparent at once on glancing through the pages of this book; for every English work, six German at least are referred to as having been consulted by the author. Apart also from its association with medical pathology, the subject is of the greatest interest to the naturalist, be he botanist or zoologist. It is only necessary to refer to the work of Pasteur in this connection for a proof of the vast amount of benefit to commerce and science which may still be anticipated to arise from a fuller knowledge of the life-histories of those organisms which are associated with so many diseases of plants, animals, and men. The importance of a study, not merely of the pathogenic or disease-producing, but of all the different species of Bacteria and Fungi is fully grasped by the author in the following paragraph: "It is impossible, by localising one's knowledge to pathogenic species to thoroughly understand the life-history of these particular forms, or to be able to grasp and appreciate the various arguments and questions that arise in comparing their life-history with the progress of disease."

The postulates formulated by Koch for establishing the exact relationship, and ascertaining beyond question whether a micro-organism associated with disease is actually the cause of that disease, are quoted by the author in the introductory chapter, and bearing as they do so intimately on the controversies which have raged over the relations of micro-organisms to disease, especially of Koch's comma-bacilli to Asiatic cholera, may be given here. They are as follows:—(*a*) The micro-organism must be found in the blood, lymph, or diseased tissues of man, or animal, suffering from, or dead of, the disease. (*b*) The micro-organisms must be isolated from the blood, lymph, or tissues, and cultivated in suitable media, *i.e.* outside the animal body. These *pure cultivations* must be carried on through successive generations of the organism. (*c*) A pure cultivation thus obtained must, when introduced into the body of a healthy animal, produce the disease in question. (*d*) Lastly, in the inoculated animal the same micro-organism must again be found.

The first part of the work is devoted to a description of the "apparatus, material, and reagents employed in a bacteriological laboratory"; to the methods employed for the "microscopical examination of Bacteria in liquids, in cultivations on solid media, and in tissues"; to the "preparation and staining of tissue sections"; to the "preparation of nutrient media and methods of cultivation"; to the subject of "experiments upon living animals"; and to the method of "examination of animals experimented upon, and the methods of isolating micro-organisms from the living and dead subject."

The multiplicity and complexity of the apparatus, materials, and reagents required for this work, and the great care and nicety in manipulation necessary for its proper execution, may well dismay the scientific inquirer who wishes to make a practical study of the subject. The expense alone of fitting up a laboratory on the lines indicated by our author, must form a great obstacle in the path of the would-be student. The license to experiment upon animals which would be necessary for a thoroughly systematic investigation is, as is now well known, most difficult to obtain. And yet there is no laboratory in this country at which such investigations could be undertaken by any one at a moderate expense. Surely London is rich enough, and earnest enough in the cause of sanitary progress, to found an establishment on the model of the Hygienic Laboratory at Berlin. There is fortunately no lack of men, thoroughly capable of undertaking its supervision, and its popularity and usefulnesy would not be a matter of doubt to those who are acquainted with the work of the Biological Laboratory at the Health Exhibition of 1884.

Part II. is "systematic and descriptive, with special microscopical methods," and commences with the history of our knowledge of Bacteria, the difficult question of classification being also here dealt with. In 1872 Cohn published his first classification. He considered the Bacteria to be a distinct group belonging to the Algæ, but from the absence of chlorophyll allied to the Fungi, and divided them into four tribes according to their shape, as globules, short rods, long rods, and spirals, these four tribes including six genera. In 1875 Cohn, in answer to Billroth, who disputed the division into species, considering that all the forms described by Cohn were but developmental forms of one organism, *Coccobacteria septica*, propounded a second classification, in which he still maintained that distinct genera and species existed. The genera Cohn considered to be distinguished by definite differences in shape, which were adhered to throughout life, while some special feature, as a difference in size or physiological action, or some minute difference in form, determined the various species. "Researches," writes our author, "by competent observers have quite recently clearly demonstrated that several micro-organisms in their life-cycle exhibit successively the shapes characteristic of the orders of Cohn. This had as early as 1873 been observed by Lister in a Bacterium in milk. Lister detected forms of Cocci, Bacteria, Bacilli, and Streptothrix genetically connected." Recent observers also have obtained similar results, so that the very foundation of Cohn's classification has been shaken, and "we are left without possessing a sound basis for classification into genera or species. The mode of reproduction is not sufficiently known to afford a better means for distinction than the other morphological appearances taken alone; nor can we depend upon physiological action, which is held by many to vary with the change of form according to altered surroundings." We have the authority, however, of Koch and Klein for believing that a Bacillus cannot change its nature, and be converted from a harmless into a pathogenic form, as asserted by Büchner.

It is usual now to regard Bacteria, yeasts, and moulds as constituting a class, the *Achlorophyllous Thallophytes*, divided into three orders: (1) *Schizomycetes* (Bacteria or fission-fungi); (2) *Saccharomycetes* (yeast-fungi); (3) *Hyphomycetes* (mould-fungi). Zopf, who, we learn, has warmly supported the pleomorphism of Bacteria, has suggested, as a result of his investigations, a division of the *Schizomycetes* into the following four groups: (1) *Coccaceæ;* (2) *Bacteriaceæ;* (3) *Leptothricheæ;* (4) *Cladothricheæ.* This classification is adopted by the author, but only as a provisional arrangement, pending increase in knowledge. "In determining," he writes, "the distinctions into species, we must take into account, not only microscopical appearances of the micro-organisms themselves, and their physiological actions, but the character of their colonies in plate cultivations, under a low power of the microscope, and the macroscopical appearances displayed in the various nutrient media. In this way, by considering each individual characteristic, Koch showed that the comma-bacillus of Finkler was a different organism from the Bacillus which was present in Asiatic cholera."

Group I., the *Coccaceæ*, are divided into five genera. Genus 1, *Streptococcus* (chain-cocci), includes the cocci found singly or in chains in acute abscesses; the cocci occurring in chains in the lymphatic channels of human erysipelatous skin, and in the fluid of erysipelatous bullæ, which produce typical erysipelas when re-inoculated in man and animals; cocci found in diphtheritic membranes and the surrounding tissues, and described as characteristic of this disease (but a Bacillus and a Bacterium have also been described as the specific micro-organisms of diphtheria); cocci of vaccine lymph, of which they are regarded as the active principle, since filtration deprives the latter of its infectious element, and successful vaccination has been stated to result from artificial cultivations. Numerous other forms are also included in this genus. Genus 2, *Merismopedia* (plate-cocci), includes *Coccus gonorrhœæ* and *Micrococcus tetragonus*, pathogenic to mice. Genus 3, *Sarcina* (packet-cocci), includes *Sarcina ventriculi*, a coccus occurring in the stomach of man and animals; *Sarcina lutea*, a non-pathogenic form; and some other forms. Genus 4, *Micrococcus* (mass-cocci), includes the coccus of yellow pus, which is also the specific organism of acute infectious osteo-myelitis, a destructive disease of the marrow of bones; the coccus of blue pus; the coccus of fowl-cholera; *Micrococcus prodigiosus*, a harmless organism which produces a blood-red colour when cultivated on potatoes; the micrococcus of septicæmia and that of pyæmia in rabbits, and numerous other forms. Genus 5, *Ascococcus* (pellicle-cocci), only one form known.

Group II., *Bacteriaceæ*, is divided into six genera. Genus 1, *Bacterium* (cocci and rods, or only rods, which are joined together to form threads; spore-formation absent or unknown), includes the *Bacterium aceti* which causes the conversion of alcohol into vinegar; the bacterium of croupous pneumonia, occurring in pneumonic exudations, which by inoculation can produce the disease in mice. Genus 2, *Spirillum* (threads screw-form, made up of rods, or of rods and cocci; spore-formation absent or unknown). In this genus is contained the spirillum of Asiatic cholera—curved rods or commas, spirilla, and threads. The commas occur isolated or attached to each other, forming S-shaped organisms or longer screw-forms, and are found in the superficial necrosed layer of the intestines, in the mucous flakes and liquid contents of the intestinal canal of cases of Asiatic cholera. They were also detected by Koch in India in a tank used to supply drinking-water. Their development is arrested by deprivation of air, and they are destroyed by drying and various antiseptics. The results of their injection into the duodenums of guinea-pigs, said to have produced choleraic symptoms, have been by others asserted to have been due to septicæmic poisoning. The difference in appearance produced by pure cultivations in gelatine-peptone broth of Finkler's comma-bacillus and Koch's cholera-bacillus are very well illustrated, and the differences in growth of these two spirilla in other media carefully described. Finkler's bacillus or spirillum has been discovered in the evacuations of cases of cholera nostras, and has been shown quite recently to be also pathogenic. In this genus is also contained the spirillum of relapsing fever, observed in the blood of patients suffering from relapsing fever, but present only during the relapses. Monkeys have been successfully inoculated from cases of the disease in man. Genus 3, *Leuconostoc* (cocci and rods; spore-formation present in cocci), contains the frog-spawn fungus, which occurs occasionally in beet-root juice, and the molasses of sugar-makers, forming large gelatinous masses resembling frog-spawn. "The vegetation is so rapid that 49 hectolitres of molasses, containing 10 per cent. of sugar, were converted within twelve hours into a gelatinous mass; consequently it is a formidable enemy to the sugar manufacturers." Genus 4, *Bacillus* (cocci and rods, or rods only, forming straight or twisted threads; spore-formation present either in rods or cocci), includes *Bacillus subtilis*, the hay-bacillus, occurring widely in air, water, and soil; *Bacillus anthracis*, or bacillus of splenic fever in cattle, and of woolsorter's disease or malignant pustule in man, of which a very full and descriptive account is given, its morphological and biological characteristics having been very completely worked out. This disease, anthrax, is one of those in which Pasteur has succeeded in attenuating the virus so as to produce a "vaccin" capable of conferring immunity on animals after inoculation. The *Bacillus tuberculosis* also belongs to this genus. The numerous methods of preparing and staining the bacilli are fully described. The bacillus of blue milk, the bacillus of malignant œdema in mice, and that of septicæmia in mice, the bacillus of typhoid fever, observed in inflamed Peyer's glands, in the spleen, mesenteric glands, and the lungs in fatal cases of typhoid fever, but not as yet imparted to animals by inoculation, the bacillus of leprosy, the bacillus of malaria, the bacillus of glanders, and some others, complete a class of micro-organisms of the greatest importance from the number of pathogenic forms it contains. Genus 5 is the *Vibrio* of ordinary putrefaction; screw-form threads in long or short links; spore-formation present. Genus 6, *Clostridium* (same as bacillus, but spore-formation takes place in characteristically enlarged rods). In this genus are the bacillus of butyric acid fermentation, which converts the lactic acid of milk into butyric acid, and produces the ripening of cheese, and the clostridium of symptomatic anthrax, the cause of "black-leg" or "quarter-evil" in cattle.

Group III., *Leptothricheæ*, contains the following genera: (1) *Crenothrix* (threads articulated, cells sulphurless, habitat water), occurring in wells and drain-pipes. (2) *Beggiatoa* (threads unarticulated, cells with sulphur-granules, habitat water), of which the best-known is *Beggiatoa alba*, or the "sewage fungus," found in sulphur-springs and marshes, as well as in sewage-polluted streams. (3) *Phragmidiothrix* (threads jointless, successive subdivision of cells is continuous, cells sulphurless, habitat water), found attached to crabs in sea-water. (4) *Leptothrix* (threads articulated or unarticulated, successive subdivision of cells not continuous, cells sulphurless), found in carious teeth.

Group IV., *Cladothricheæ* (possessing cocci, rods, threads, and spirals: thread-forms provided with false branchings), contains *Cladothrix dichotoma*, said to be the commonest of all Bacteria in both still and running water, in which organic substances are present.

Amongst species of Schizomycetes mentioned by writers, and not described or not recognised as distinct species in the preceding classification, are *Micrococcus indicus*, *Micrococcus septicus*, *Micrococcus endocarditicus*. The micrococci of measles, scarlatina, cerebro-spinal meningitis, typhus, acute yellow atrophy of the liver, whooping-cough, puerperal fever, gangrene, yellow fever, dental caries, and saliva. Most of these organisms are only known to be associated with the diseases in question, the causal relations, if existent, have yet to be determined. In this chapter are also described *Bacterium termo* of common putrefaction, *Bacterium lactis*, *Bacillus figurans*, the bacillus of swine fever, the bacillus of choleraic diarrhœa from meat-poisoning, the bacilli of septicæmia in man, of syphilis, and of rhinoscleroma, the comma-bacillus of the mouth, various forms of spirillum and monas, *Proteus vulgaris*, described as intimately connected with the process of putrefaction, *Actinomycetes*, said to be the cause of actinomycosis, a disease of the jaws and lungs in men and animals, and many others too numerous to mention.

An appendix is devoted to the consideration of the yeast-fungi, or *Saccharomycetes*, and of the mould-fungi, or *Hyphomycetes;* under the latter are described the various species of *Mucor*, *Oidium*, *Aspergillus*, &c. The volume concludes with an account of Koch's methods for the examination of air, water, and soil, with a view to the detection and recognition of their contained micro-organisms.

Enough has probably been said to show the wide range covered in this work and the full and able manner in which its matter has been treated. On the importance of the subject and the want that has been supplied by the production of a work that has condensed into one volume a subject, the literature of which in English is diffused in numerous reports and periodicals, we have already remarked. The numerous coloured plates of test-tube and potato cultivations and those of microscopic appearances are admirably designed and executed, and greatly enhance the value of the work.

The book, we believe, will be widely read and appreciated by all interested in science.

THE ANATOMY OF THE NETTLE

*Recherches anatomiques sur les Organes végétatifs de l'*Urtica dioica, *L.* By A. Gravis. (Brussels, 1885.)

A WORK of more than 250 pages devoted exclusively to the anatomy of the vegetative organs in one species of nettle is a publication of a somewhat unusual kind, even in these days of scientific specialisation. The author has evidently bestowed a vast amount of labour on his subject. He states in his introduction that no less than 15,000 sections had to be made in the course of his investigation of this one plant, and twenty-three beautifully executed plates bear witness to the laborious accuracy with which the work has been carried out. The treatise is one which hardly admits of an abstract, as in a monograph of this kind details are everything. We shall only attempt to give a sketch of the order in which the author has arranged his facts, and to indicate one or two points on which his conclusions have some general interest.

The investigation was originally intended to serve as a basis for a general comparative study of the family Urticaceæ. The question of the value of anatomical characters in classification is one which has engaged the attention of many botanists during the last few years. So far the results have proved of very unequal importance in different cases. The author notices the much more considerable part played by anatomy in zoological than in botanical classifications. This he attributes in a great degree to the frequent neglect on the part of botanists to examine every part of the plant in question, at all ages, and under varying biological conditions. Too often one or two sections are made, almost at haphazard, from each species, with the result that things not truly comparable are frequently compared. One of the main objects of the work before us is to show how great the variations are which are due to the differences just mentioned.

The treatise is divided into three parts, devoted respectively to the stem, the leaf, and the root. The first part begins with a general account of the external conformation of the stem of the nettle, and its systems of subaërial and subterranean branches. For the purposes of his exposition the author divides the stem into *segments*, each segment including a node, with the lower half of the internode next above it and the upper half of that next below it. He then proceeds to classify the variations of structure investigated. First he distinguishes variations *according to level*, by which he indicates the different structures shown by transverse sections of different parts of the *same* segment, the most important of these differences being those between the nodal and internodal structure. Next come variations *according to age*, namely, those which are presented by corresponding sections taken at different periods of development. The third